

Design, Development and Manufacturing of Roll Cage for Self-Propelled Onion Harvester

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ABSTRACT: India is second largest country which produces onion, but most of time conventional method is used to harvest the onion. It will take lot of time to harvest the crop. To optimise the timing and improving the productivity a specific machine is needed which harvest the crop and reduce the time. This paper gives detailed information regarding design, development and manufacturing of roll cage for self-propelled onion harvester. Design of roll cage depends on parameters like operator comfort, position of various part such as drive train position, steering, braking, engine position and its strength and stiffness. Modelling of roll cage is carried out on solid works and FEA is carried out on ANSYS V 17.1. Our main aim is to optimise design which improve strength of roll cage and reduction of weight.

KEYWORDS: Harvester, Operator comfort, Solid works, Static structural, Ansys, Optimising, FEA, Strength, Stiffness, Roll cage

I. INTRODUCTION

India is known for agricultural which affects its economy. Indian onion has two crop cycle from June to October and from January to March. In India most of the cases harvesting of crop cycle done by manual method which is too time consuming, to eliminate this drawback and to improve productivity it is necessary to design and manufacture self-Propelled onion harvester. The roll cage of harvester is integrated frame work which support the component like engine, gear box, steering, Braking assembly. The roll cage design for onion harvester has front wheel drive and rear wheel steering. As harvester has front wheel drive most of the weight is on front side so proper weight distribution is taken out. The constrain which was consider during design of roll cage was operator comfort, Position of component, ergonomic consideration and rule book restriction. The solid works software is used for modelling of roll cage. During the modelling optimisation of weight and improving the strength is our prime moto. To check the design is satisfied required condition or not FEA is carried out using software ANSYS. Roll cage is manufactured to maximum load capability, durability, as well as adequate performances.

OBJECTIVES

1. To analyse and evaluate the performances of existing harvester chassis.
2. To design and analyse the chassis for new harvester.
3. To manufacture the chassis and evaluate its performance.

II. DESIGN OF ROLL CAGE

Design of roll cage is based on various constrain such as position of component, comfort to driver, safety to driver and various ergonomic consideration like better visibility to driver and optimisation of weight and improving strength with minimum possible cost. For design of any roll cage modelling is major part. Solid work software is used for modelling of roll cage were firstly 3-dimension sketch is draw keeping in mind various constrain. Applying various command to draw the sketch the most useful command is weldments. Hollow square section is selected for modelling of chassis.

OVERALL SPECIFICATION

1. Machine type: four wheels
2. Ground clearance: 250 mm
3. Track width: 1125 mm



4. Overall width: 1100 mm
5. Overall length: 2490 mm
6. Overall height: 1500 mm
7. Driver position: At right hand side of vehicle.
8. Engine position: At left hand side of vehicle.

CALCULATION:

1) Bending Strength (Bs) = $(S_y \times I) / C$

Where,

S_y = Yield strength

I = Second moment of area for the structural cross section.

C = Distance from neutral axis to extreme fibre.

2) Moment of Inertia:

$I = (a^4 - b^4) / 12$

$I = (40^4 - 37^4) / 12$

$I = 57.15 \times 10^3 \text{ mm}^4$

3) Distance from neutral axis to extreme fibre = C = 20mm

Yield tensile strength = S_y = 326.15 MPa

4) Bending Strength (Bs)

= $(S_y \times I) / C$

= $(326.15 \times 57.15 \times 10^3) / 20$

= $931.9 \times 10^3 \text{ Nmm}$

5) Bending Stiffness

= E x I

= $205 \times 10^6 \times 57.15 \times 10^3$

Bending Stiffness = $11.715 \times 10^{12} \text{ Nmm}^2$

SELECTION OF MATERIAL

The parameters which are consider during selection of material are its mechanical properties like tensile strength, yield strength, percentage of elongation, young modules, density, hardness as well as chemical properties like % C, % Si, % P etc. The material is selected on the basis of the material sustain all the loading condition like self-load, load applied due to sudden braking and acceleration. ASTM !06 grade b is selected for roll cage manufacturing as it has all the properties as per requirement.

Table – 1: Chemical properties of material

Element	content
% C	0.188
% Si	0.213
% Mn	0.836
% P	0.018
% S	0.014
% Ni	0.067
% Cr	0.052

Table – 2: Mechanical properties of material

Mechanical properties	Unit value
Tensile Strength	598.43 M pa
Yield Strength	326.15 M pa
% Elongation	49.78
Youngs Modules	210 M pa
Density	7850 Kg/m3
Hardness, Brinell	241
Poisson ratio	0.3

III. FINITE ELEMENT ANALYSIS OF ROLL CAGE

To check our design, sustain required condition or not finite element analysis is carried out by using software Ansys. In this we carried out test like total deformation, Equivalent stress, Equivalent strain, Maximum shear stress. Ansys workbench software is used to perform this task. Creating nodes and element is first task in any analysis so meshing of body is carried out to perform finite element analysis were body is divided into small number of nodes and element. There are two type of meshing, fine meshing and course meshing. We did fine meshing for our roll cage. If meshing is fine then result obtain is accurate and if meshing is course then there is some deflection in result. The total number of nodes and element formed are shown in below table. All the loading condition acting on roll cage are static and analysis is of static structural type. There are four types of load acting on roll cage which are self-weight which is vertically downward, engine, gearbox weight which also act vertically downward direction then load due to provision of digging blade which acts in z direction and due to provision of hydraulic cylinder for lifting blade up and down and running of conveyor.

MESHING OF ROLL CAGE:

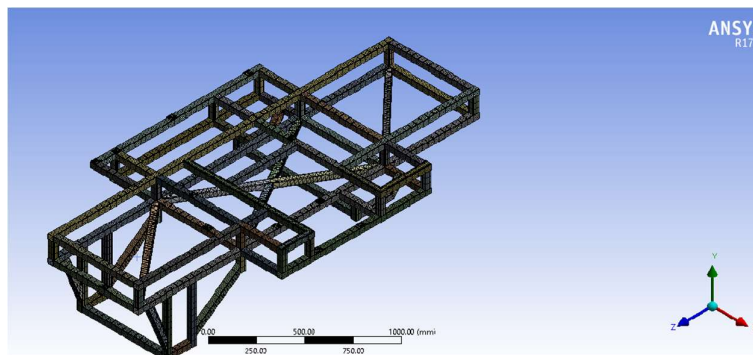


Fig. – 1: Meshing.

Table – 3: Statistics

Entity	Size
Nodes	384786
Element	78986

STATIC ANALYSIS:

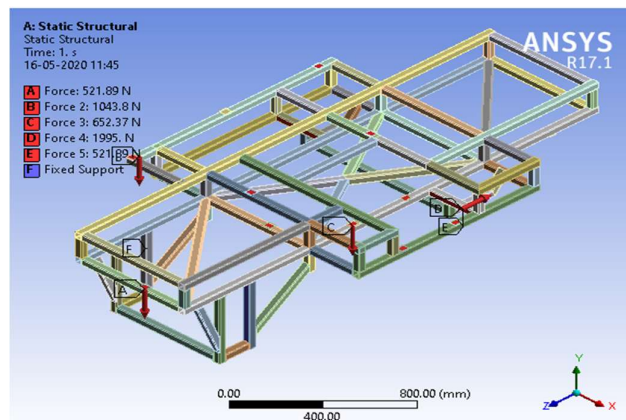


Fig. – 2: Forces acting on roll cage.

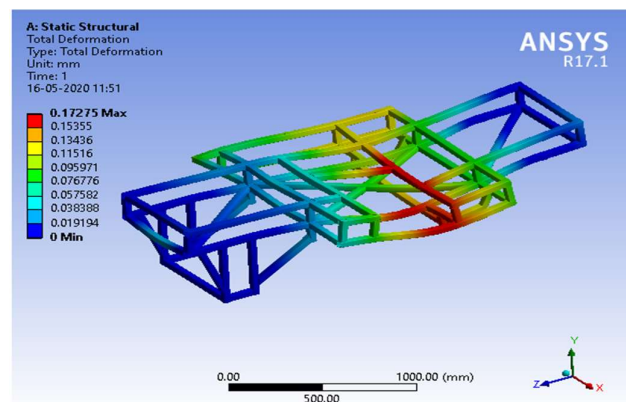


Fig. – 3: Total Deformation.

Table – 4: Tabular Data (Total Deformation)

Sr. No	Time[S]	Minimum[mm]	Maximum[mm]
1	1.	0.	0.17275

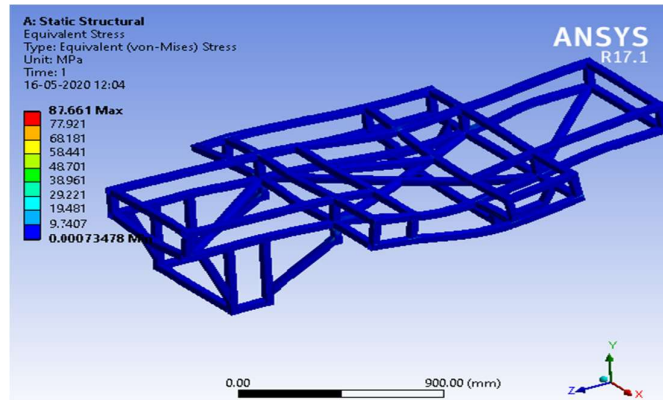


Fig. – 4: Von misses stress.

Table – 5: Tabular Data (Von Misses)

Sr. No	Time[S]	Minimum [MPa]	Maximum [MPa]
1	1.	7.3478e-004	87.661

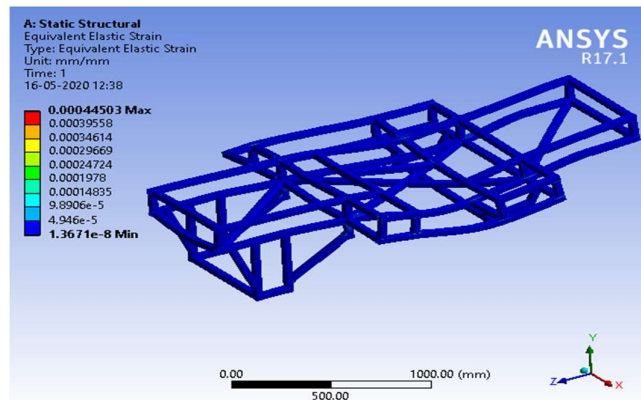


Fig. – 5: Equivalent Elastic Strain

Table – 6: Tabular Data (Equivalent Elastic Strain)

Sr. No	Time[S]	Minimum [MPa]	Maximum [MPa]
1	1.	7.3478e-004	87.661

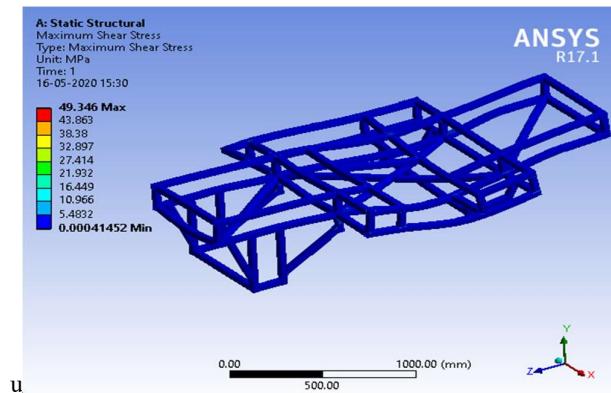


Fig. – 6: Maximum Shear stress.

Table – 7: Tabular Data (Maximum shear stress)

Sr. No	Time[S]	Minimum [MPa]	Maximum [MPa]
1	1.	4.1452e-004	

RESULT:

From above theoretical calculation of bending strength and bending stiffness and experimental result got from finite element analysis it is seen that maximum stress on roll cage is about 87.661 MPa which is equivalent stress and this stress is smaller than bending strength which is about 931.9×10^3 Nmm. Bending strength is maximum strength below which all stress sustain by roll cage. Also, the total deformation is about 0.17275 mm which is also negligible. This roll cage sustains all kind of load which are acting on it without any deformation and failure.

IV. FABRICATION OF ROLL CAGE

Following are the steps taken for fabrication of roll cage.

- 1) Cutting: Initially hallow square sections cut into different size pieces as per the design with the help of cutter machine.
- 2) Prepare Fixture: Once material is cut as per the requirement further these pieces are goes to welding process. But before going to welding process for easiness of welding process fixtures are prepared according to design and welding is done.
- 3) Welding Process: After placing square section into fixtures according to design welding process is carried out. Welding technique used for roll cage is arc welding. Arc welding is process of joining two metal parts by means of electricity. Electricity is used to melt the metal and weld two metal parts. Arc welding is easy process.
- 4) Provision of mountings: Different mountings are provided to roll cage so as to mount and support other assembly. Mount like toe provision, engine mount, seat mount, gear box mount, bushing for engine for damping vibration are provided.
- 5) Grinding: Grinding is used to finish work pieces that must show high surface quality and high accuracy of shape dimension.
- 6) Painting: This is last step in fabrication of roll cage. To avoid and as part of aesthetic roll cage is painted with colour.



V. CONCLUSION

This project is about design, analysis and development of roll cage also this project has considered a variety of issue related to frame and roll cage design with an emphasis on TIFAN vehicle. The different roads load and deformation modes were considered as well as some generic design targets based on rule book provided by TIFAN. A simple mathematical model was developed for comparing the structural stiffness to gain insight into proper design targets for the vehicle structure. These charts also aid in visualizing the trade-offs between stiffness and weight the designer must make. With these stiffness targets in mind, a finite element model was constructed for entire chassis. This model was constructed and analysed in ANSYS. This roll cage best captures load paths and easily performed by teams as they prepare for competition.

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